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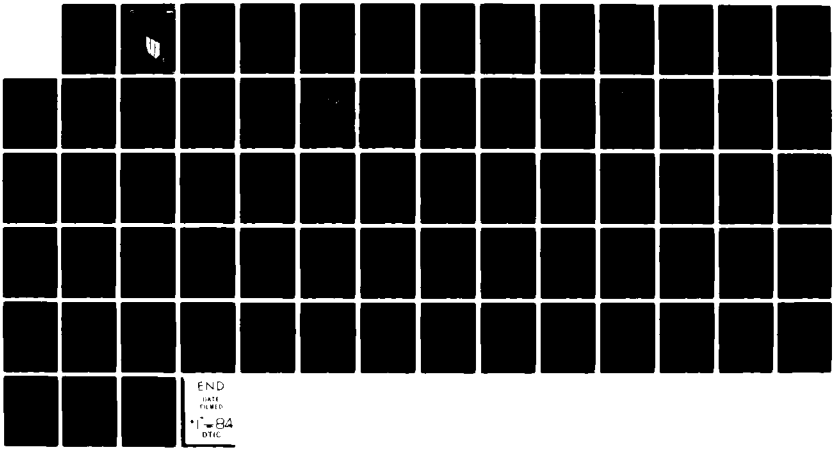

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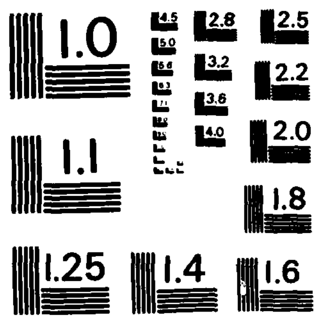

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US Army Corps
of Engineers
Construction Engineering
Research Laboratory

CERL

Technical Report E-188
October 1983
(Military Construction Energy Design
Strategy Program Development)

ENERGY IMPACT ANALYSIS OF THE MILITARY CONSTRUCTION—ARMY BUILDING DELIVERY SYSTEM

by
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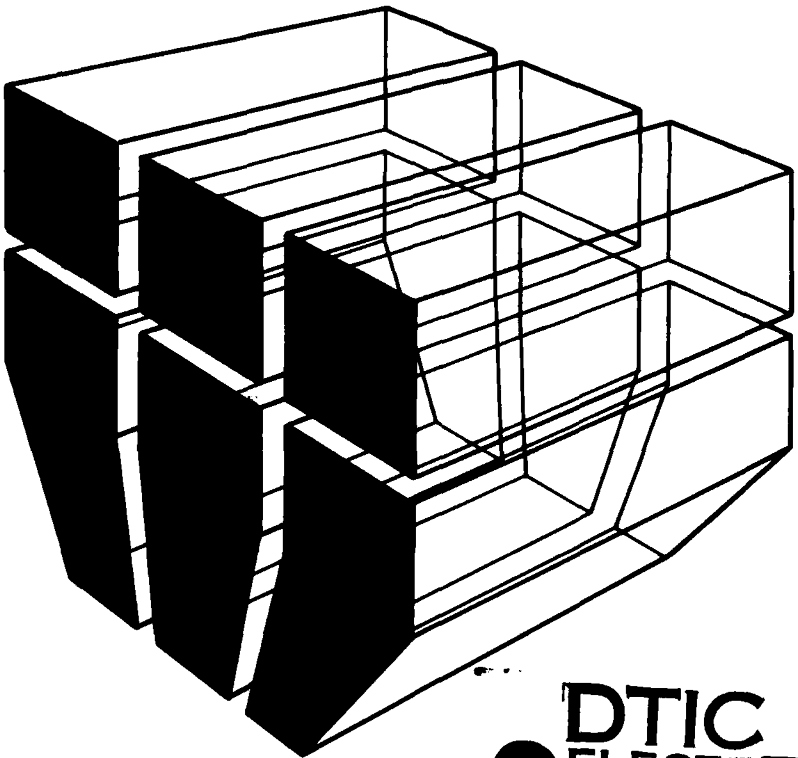

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The objectives of this study were to do an energy impact analysis of the Military Construction -- Army (MCA) building delivery process to assess how energy conservation can be more effectively implemented into the process, and to recommend where additional work is needed to develop: (1) proposals for modifying the actions taken during the MCA process in order to make new Army facilities more energy efficient, (2) requirements for energy analysis tools

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and procedures to help improve energy conservation, and (3) research and development requirements for improving the energy efficiency of buildings.

To achieve these objectives, the following steps were taken:

1. To identify the phases in the MCA building delivery system and the functional relationhips among them, Army Regulation (AR) 415-15, AR 415-20, and AR 415-10 were analyzed. Also analyzed were the results of a joint project by the Office of the Chief of Engineers and the U.S. Army Construction Engineering Research Laboratory titled Responsiveness Analysis of Military Programs (RAMP).

2. In addition to the documents reviewed in Step 1, Department of Defense, Department of the Army, and U.S. Army Corps of Engineers documents which affect decisions made during the MCA process were analyzed. These analyses were used along with information from contacts at Corps Divisions and Districts to determine what actions take place during the MCA process and their impact on energy consumption of completed facilities.

3. The MCA process was divided into functional phases to emphasize areas where energy impacts were likely to occur.

4. Using the document analysis of Step 2, an energy impact analysis was done for the MCA functional steps identified in Step 3 to identify where deficiencies in implementing energy conservation in the MCA process might occur. This analysis also used information collected from discussions with Corps personnel and from an evaluation of the design methods of the Department of Energy, other Government agencies, and private industry.

5. Actions which could improve the energy effectiveness of the MCA process were identified and research and development requirements were developed.

The results of the energy impact analysis show that the present MCA process does not hinder the delivery of energy-efficient buildings. However, the MCA process does not ensure that energy-efficient buildings will be delivered, nor does it encourage personnel involved in the MCA process to produce an energy-effective facility. Further, the energy impact analysis shows that while there are significant requirements in the MCA process for considering conservation and alternate energy sources, not enough guidance is available on how to effectively address those requirements.

This report also shows that the MCA process assesses energy impacts primarily during the late concept and final design phases. Only a little attention is directed to energy impacts during planning, programing, early concept design or construction, even though decisions at these phases can significantly affect the energy consumption of the final building. The criteria and energy analysis tools needed for late concept and final design are available, but the design methods and review procedures do not ensure these tools are being properly used.

FOREWORD

This work was performed for the Directorate of Engineering and Construction, Office of the Chief of Engineers (OCE), under Project 4A762781AT45, "Energy and Energy Conservation"; Technical Area A, "New Construction Energy Design Strategy"; Work Unit 001, "Military Construction Energy Design Strategy Program Development." Mr. Ron Hubbard, DAEN-ECE-A, was the OCE Technical Monitor.

This research was performed by the Energy Systems (ES) Division of the U.S. Army Construction Engineering Research Laboratory (CERL). Appreciation is expressed to Mr. Patrick O'Meara of OCE for his assistance, suggestions, and guidance during this study. Appreciation is also expressed to Messrs. Charles Lozar, Alan Moore, Robert Neathammer, and Michael Hershenson of CERL. Mr. R. G. Donaghy is Chief of ES.

COL Paul J. Theuer is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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ENERGY IMPACT ANALYSIS OF THE MILITARY CONSTRUCTION -- ARMY BUILDING DELIVERY SYSTEM

1 INTRODUCTION

Background

To ensure that new Army buildings will save as much energy as possible, as mandated by the Army Energy Plan, energy conservation must be considered during all phases of the building delivery process.[1] Energy conservation will be effectively implemented only if all personnel involved in the MCA process have the proper tools, guidance, and data to properly assess the impacts of alternate energy sources, and to produce practical and reliable designs for energy-efficient facilities.

The majority of energy conservation decisions are currently made during late concept and final design phases. These decisions are made using computer-aided energy analysis tools and criteria such as design energy budgets which are available during these phases. Conservation has not been taken into account as effectively during the long-range planning, master planning, programing, early concept design, and construction phases because the required data, analysis techniques, procedures, and guidance have not been readily available. As most personnel involved in the MCA process know, however, the decisions they make during these phases of the building delivery process will significantly affect a building's ultimate energy consumption. Thus, energy considerations must be incorporated into the entire Military Construction -- Army (MCA) process.

To do this, the U.S. Army Construction Engineering Research Laboratory (CERL), performed an energy impact analysis of the entire MCA building delivery system. This analysis was used to define the energy-sensitive steps and decision points in the MCA process. The analysis was also used to determine whether there were any deficiencies in the process which prevented the effective consideration of energy conservation measures. When problems were identified, research and development requirements were proposed to improve the overall energy efficiency of the facilities provided by the MCA process.

Objective

The objective of this study was to do an energy impact analysis of the MCA building delivery process to (1) assess how energy conservation can be better implemented in this process, (2) define potential areas where modification of actions taken during the MCA process could make new Army facilities more energy effective, (3) define the needs for energy analysis tools and procedures to help implement energy conservation, and (4) define research and development (R&D) needs for improving the energy efficiency of buildings.

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[1] Army Energy Plan, ADA057987 (Department of the Army, 24 February 1978).

Approach

To achieve this objective, the following steps were taken:

1. To identify the phases in the MCA building delivery system and the functional relationhips among them, Army Regulation (AR) 415-15, AR 415-20, and AR 415-10 were analyzed, as were the results of a joint OCE/CERL project, Responsiveness Analysis of Military Programs (RAMP).[2]

2. Department of Defense (DOD), Department of the Army (DA), and U.S. Army Corps of Engineers (CE) documents which affect decisions during the MCA process were analyzed. This information was used with the document analysis of Step 1 and contacts at Corps Divisions and Districts to determine what actions take place during the MCA process, and to define the impact of these actions on the final facilities energy consumption.

3. The MCA process was divided into functional phases to highlight areas where energy impacts were likely to occur.

4. An energy impact analysis, using the document assessment of Step 2, was done for the MCA functional steps identified in Step 3 to identify where deficiencies in implementing energy conservation in the MCA process might occur. This analysis also used information collected from discussions with Corps personnel and from an examination of the design methods of the Department of Energy, other Government agencies, and private industry.

5. Actions which could be taken to improve the energy effectiveness of the MCA process were identified. Research and development requirements were developed for these actions. This list of actions and R&D requirements forms the overall strategy for improving the energy conservation considerations within the MCA process.

Mode of Technology Transfer

The information in this report will lead to recommended changes in actions taken during the MCA process and in the documents which define the process.

[2] MCA Program Development, AR 415-15 (Headquarters [HQ], Department of the Army [DA], 1975) and Draft Version dated December 1981; Construction, Project Development and Design Approval, AR 415-20 (Headquarters [HQ], Department of the Army [DA], 1974) and Draft Version dated January 1982; Construction, General Provisions for Military Construction, AR 415-10 (Headquarters [HQ], Department of the Army [DA], 1972).

2 THE MILITARY CONSTRUCTION -- ARMY PROCESS

Before the MCA process could be analyzed for energy impacts, its functional phases and their interrelationship had to be identified. To do this, CERL examined the documents which define the MCA process. The documents included AR 415-10, AR 415-15, and AR 415-20, and the results of the ongoing RAMP study.

Since the MCA process is extremely complex and not completely defined by any one document, any breakdown of the process into functional components is somewhat arbitrary and depends on the purpose of the analysis. For this study, the various functions were selected to highlight the points during the planning, programing, design, and execution of the MCA process where energy impacts or problems are likely to occur.

MCA Program

The framework for the overall building delivery process is contained in AR 415-10, AR 415-15, and AR 415-20. These documents define the MCA program development cycle. This cycle is comprised of the series of actions taken to plan, program, design, budget, and deliver a completed facility at a construction site. The MCA program development flow chart (Figure 1) is based on similar charts provided in AR 415-15. The MCA actions are given in terms of (1) the guidance year, (2) the design year, (3) the budget year, and (4) the program or construction year. Each activity requires various reviews and decisions -- from Congress to the facility engineer, to the ultimate users of the building. The actions are defined in Table 1.

Five major activities are associated with the MCA process: (1) planning and program development, which define the need for the building and establish the functional requirements; (2) the design process itself, which is generally handled by contractors to Corps districts; (3) review activities, which periodically evaluate the planning and design at all levels (from the user to Congress); (4) approval activities, which authorize the design team to begin and continue its work; and (5) construction, where the facility is constructed.

To monitor the building design, including its energy efficiency, during these MCA activities, CE uses requirements documents and design reviews. The information specified in DOD, DA, and CE documents delineates processes and procedures, and sets requirements to be met in the MCA process. Most of the Army's design work is contracted to private architect/engineer (A/E) firms. The design decisions of these firms are monitored by the district and division personnel who review A/E submissions for compliance with these documents.

Four types of reviews are used to help control the flow and content of MCA projects. Data reviews, primarily used at the early stages of project development, check that project requirements are being met. Budget/cost reviews, held along with data reviews and throughout project life, determine the feasibility of design components and ensure compliance with project budget ceilings. Design reviews evaluate all design components for compliance with

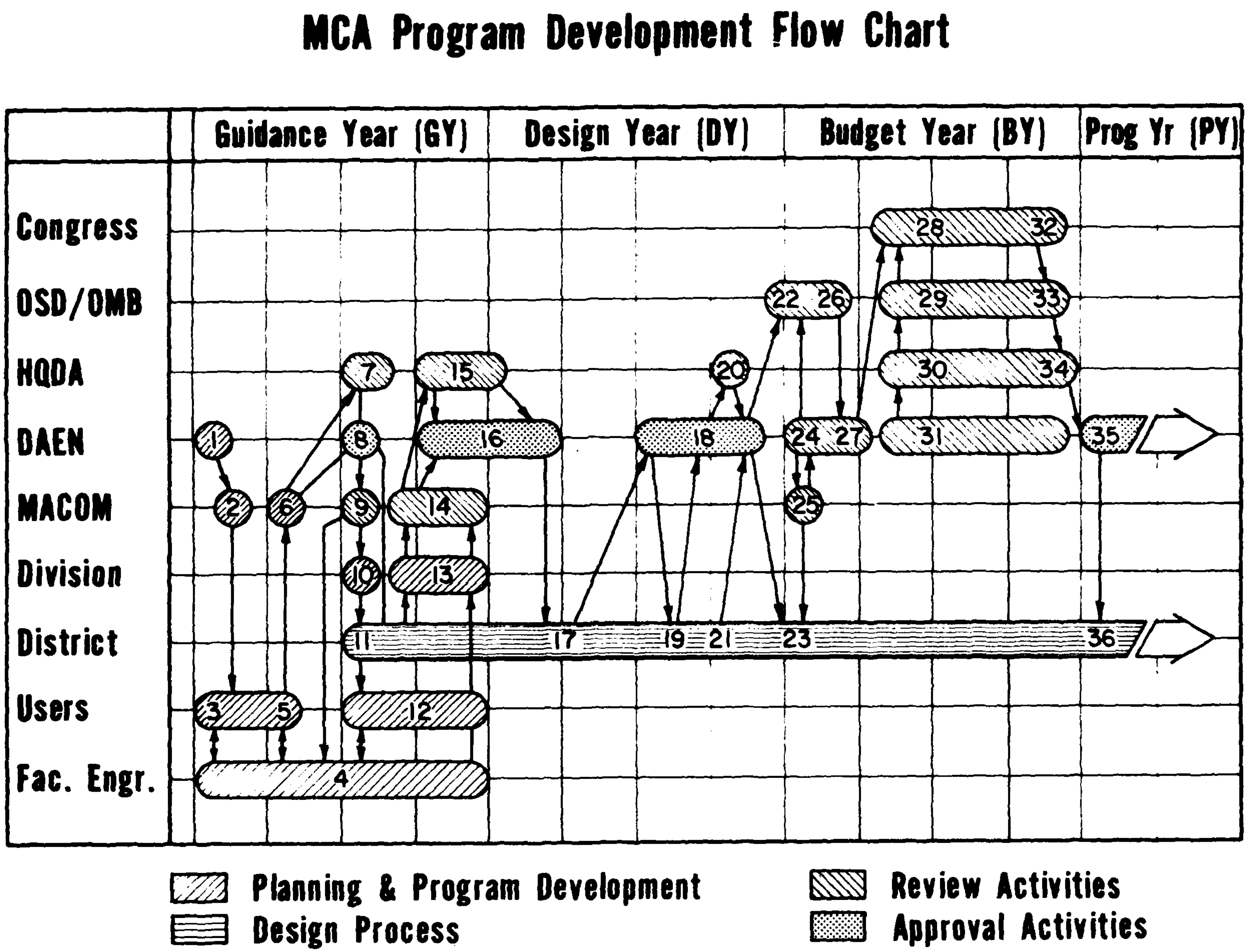

Figure 1. MCA program development flow chart.

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Table 1

MCA Cycle Steps*

1. HQDA POM guidance and MCA program guidance to MACOMS.
2. MACOM guidance to installations.
3. Facility Engineers develop prioritized installation program.
4. Using agencies provide functional requirements of projects in program.
5. Installations submit prioritized front page 1391s.
6. MACOM submits prioritized program front page 1391s to HQDA and DAEN-ZCP-M.
7. CRRC formulates Army-wide Prioritized Program, releases projects for Code 1 activities and provides guidance to MACOMs.
8. CE directs Code 1 activity to District.
9. MACOMs provide guidance to installations; request full 1391 and PDB preparation.
10. Divisions review program, progress, schedules of districts.
11. Districts initiate Code 1 activity, prepare for initiation of design.
12. Prepare, submit full 1391s and PDBs to MACOMs, divisions.
13. Divisions review 1391, PDBs, provide comments to MACOMs.
14. MACOM prepares MACOM FYP, submits program to HQDA and DAEN-ZCP-M.
15. CRRC develops GY program, releases projects for design.
16. Technical review, release by CE for concept design.
17. Districts initiate concept design (Code 2), send PCCD to CE.
18. Adjust project costs (incl. concept level costs), submit to CRRC, direct final design; prepare program/budget, submit to OMB/OSD.
19. Submit concept level cost data to CE.
20. Final CRRC review, adjustment -- PBC, CSA review/approval.
21. Districts accomplish final design (Code 6) by BY program.
22. OSD/OMB review, adjustment of program.
23. Districts prepare, submit supplemental justification data to MACOMs.
24. Review, consolidate, and submit supplemental justification data for prior year's planning and design for OSD.
25. MACOMs prepare, submit supplemental justification data to CE.
26. Review and release annual MCA program for inclusion in "President's MILCON Budget."
27. Prepare all approved data for inclusion in President's MILCON Budget.
28. Congress reviews budget submission, hearings held, questions issued.

29,30,31. OSD, HQDA, CE testify, answer questions, provide data to Congress.

32. Authorization and Appropriation Bills produced; effective 1 October.
33. Apportionment by OMB on or after 1 October.
34. Allocation by USAFAC in October.
35. Allotments to Districts by CE begin in October.
36. Construction begins.

*Acronyms: BY: Budget Year; CE: Corps of Engineers; Code 1: Design Code; Code 2: Design Code 2; Code 6: Design Code 6; CRRC: Construction Requirements Review Committee; CSA: Chief of Staff, Army; DAEN-ZCP-M: Office of the Chief of Engineers, MILCON Management Branch; FYP: Five-Year Program; GY: Guidance Year; MACOM: Major Command; MCA: Military Construction, Army; MILCON: Military Construction; OMB: Office of Management and Budget; OSD: Office of the Secretary of Defense; PBC: Program and Budget Committee; PCCD: Pre-concept Control Data; PDB: Project Development Brochure; POM: Program Objectives Memorandum; USAFAC: U.S. Army Finance and Accounting Center.

design requirements. Construction inspections and testing ensure that the facility is constructed as designed.

The RAMP Project

The Corps continually evaluates how well the MCA process delivers facilities responsive to the users' needs. As part of this evaluation, CERL's RAMP project attempts to:

1. Describe and define the current process of military construction planning and decision-making.

2. Collect data to verify the accuracy of those descriptions and definitions.

3. Analyze the data for timeliness and responsiveness to directives.

4. Develop improved schedules and supporting documentation for the MCA construction program development and decision-making processes.

Information collected during the RAMP project was used extensively to (1) help in the review of the MCA process, (2) identify documents which define the process, and (3) expand the identification of MCA steps depicted in Figure 1 so that an energy impact analysis of the overall MCA process could be done.

Evaluation of Documents Governing the MCA Process

The starting point for the energy impact analysis was a review of the documents governing the MCA process to define the functional steps and their energy impacts.

Document guidance covering the project development phase of the MCA process deals with the relationship of the proposed facility to its installation, justification for the facility, and the specification of various building functions and user needs. Document guidance covering the design phase describes the development of concept designs, requirements for engineering feasibility studies and cost trade-offs, minimum acceptable criteria for certain engineering and design practices, cost estimating procedures and the development of contract documents. For the construction phase, documents give guidance on construction details, inspection procedures, and construction administration.

In addition to documents for particular phases of the MCA process, general Army guidance documents govern major aspects of the MCA process which relate to design and energy consumption. These documents are not specific to

a particular stage of design, but influence decision-making throughout the design process.[3]

Appendix A lists the MCA documents CERL identified as governing building energy consumption; it gives a short description of the purpose of each document, indicates which parts of the document relate to energy consumption, and provides a short commentary on how the document affects facility energy consumption. Although many of the documents described do not specifically mention energy, they do affect energy-related decisions made during the design process.

Functional Phases in MCA Process

The evaluation of the documents listed in Appendix A showed that the decision requirements allow one to divide the MCA process into the following major phases: project development (including long-range planning, master planning, and programing), design (including concept and final design), and construction. These major phases, depicted in Figure 2, are divided into activities that are governed by existing Army documents. Actions during each activity produce results which provide justification for whether to proceed to the next phase of the MCA process. These activities are summarized in Table 2. Figures 3 through 8, at the end of this chapter, list activities, outputs, and documents for each phase. Each of the six phases is discussed below.

Long-Range Planning

Long-range planning is generally done at higher headquarters such as major commands (MACOMs), DA, DOD, National Security Council (NSC), or Congress. Long-range planning is associated with planning for missions and mission changes. Long-range planning activities that affect the Army's facility requirements include: stationing decisions, such as expansions or contractions of the Army; economy measures, such as consolidation of bases or facilities; and force structure planning, such as reorganizations of the Army to meet new threats or to more effectively meet old threats. Facility decisions made during this phase involve the evaluation of whether existing facilities can meet the mission requirements; if not, it must be determined whether existing facilities can be renovated or new facilities must be provided. Part of this long-range planning phase is the preparation of facility requirements for new weapon systems and mobilization planning.

This phase provides MACOMs and installations with Army guidance which may lead to the modification of installation master plans. Modifications are coordinated at all levels, including the installation commander and ultimate user, and lead to the master planning phase of the MCA process.

[3] Such "general information" documents include Design Policy for Military Construction, Engineer Regulation (ER) 1110-345-100 (OCE, 14 December 1973); Construction Criteria for Army Facilities, Technical Manual (TM) 5-800-1 (HQDA, 10 September 1974); Army Energy Program, AR 11-27 (HQDA, 15 October 1982); and Construction Criteria Manual, DOD 4270.1-M (DOD, 1 June 1978).

Table 2

MCA Phases and Actions

	PROJECT DEVELOPMENT		PROJECT DESIGN			EXECUTION
Long-Range Planning	Master Planning	Programing	Early Concept	Late Concept	Final	Construction
* Force Structure	* Project Definition	* Prepare Detailed DD Form 1391 & PDB2	* Space Planning	* Building Systems design	* Working drawings	* Contractor selection
* Installation planning	* Initial DD Form 1391 preparation	* Facilities requirements	* Functional analysis	* Systems analysis	* Buildings specifications	* Building construction
* Mobilization planning	* PDB1 preparation	* Economic analysis	* Cost analysis	* Design analysis	* Contract documents	* Building acceptance
	* Functional & capability planning analysis		* Energy analysis	* Outline specifications		* As-built drawings
	* Functional & technical planning analysis		* Prepare concept control data	* Cost analysis		* Building operation & maintenance documentation
	* Update general site plan & prepare detailed site plan		* Selection of architect/engineer			
	* Prepare cost estimates					

Master Planning

Once stationing and mobilization plans have been formulated at higher levels, the installations must determine what real property changes are needed. During the master planning process installation planners evaluate regional impacts, environmental concerns, utility requirements, existing services, and land use patterns for new facilities. These concerns are recorded in the installation's master plans and documents.

For new facilities, an initial DD Form 1391 and a Project Development Brochure (PDB1) is produced. These documents list the users' functional requirements, justify the need for the facility, and provide initial cost data. These documents are sent to the MACOMs where they are prioritized for inclusion in the MACOM 5-year program.

Programing

After design code 1 is received through channels from the Chief of Engineers (COE), the district contacts the installation to begin detailed programing requirements for the facility. Planning at this stage becomes facility and site specific. Detailed functional requirements and cost estimates are prepared in the PDB2 and DD Form 1391. After programing is completed, clear functional requirements, budget requirements, and design priorities are set for the facility. The district may further elaborate on these requirements in its instructions to the A/E team when starting concept design.

Concept Design

After design code 2 is received, the district selects the A/E team to design the facility if it is not being done in-house. After negotiation has been completed and the A/E contract awarded, concept design begins. For the purposes of this report, concept design has been divided into early and late concept design. Early concept design takes up 0 to 10 percent of the design process. This step in the design process deals primarily with architectural layout and the meeting of functional and aesthetic considerations. Several conceptual designs are developed and evaluated. After the design alternative that best satisfies the programing requirements is chosen, late concept design begins. Late concept design takes up 10 to 35 percent of the design process. The design chosen in the early concept design is modified during late concept design to incorporate any review comments (if reviewed or commented on at this point) and to upgrade it to a full-concept design. Upgrading the design involves the refinement of the architectural design and the initial layout of the electrical, mechanical, and structural systems. Site plans, architectural drawings (floor plans, sections, elevations), outline specifications, and initial plans for the building systems are produced. The cost estimate is updated and the building design is checked for compliance with energy budgets.

Final Design

The final design phase produces all documentation and drawings needed to solicit realistic bids and to construct a finished facility. Building components and systems are designed to final detail (i.e., structural; heating, ventilating, and air conditioning [HVAC]; plumbing; and electrical) and the final drawings are completed. This phase also produces the technical

specifications, contract documents, bid package, and the final cost estimate for the facility.

Construction

The last phase of the building delivery process is construction. During this phase, the Corps ensures that the facility is built according to the design and supervises all change orders. Construction ends with final building acceptance. This phase produces a building ready for occupancy, a complete set of as-built drawings, and facility maintenance and operational instructions.

The next section of this report describes the energy impacts for each of these phases in the MCA process on the final facilities energy consumption. The section also lists the actions and R&D requirement for improving the energy effectiveness of the process.

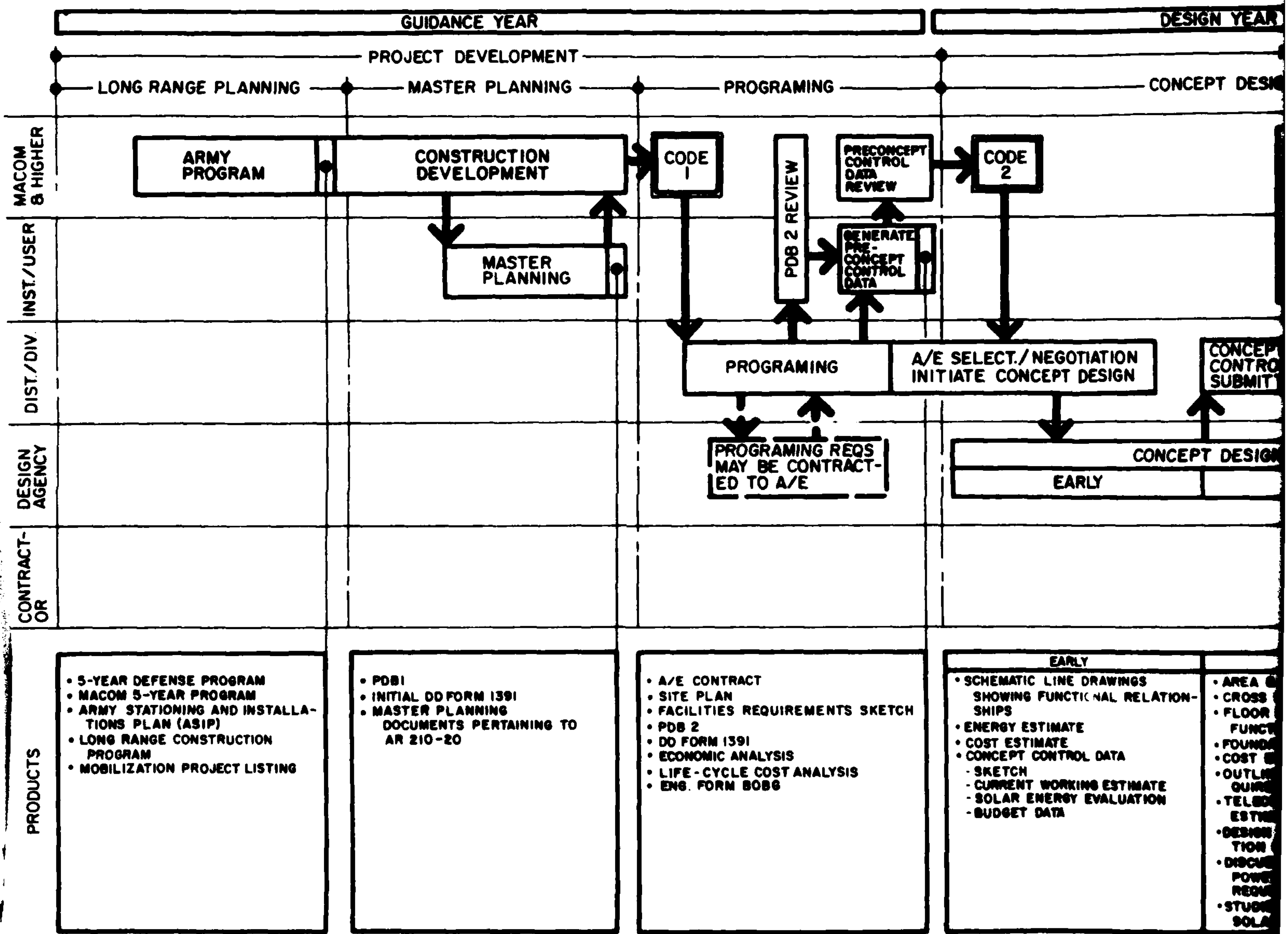
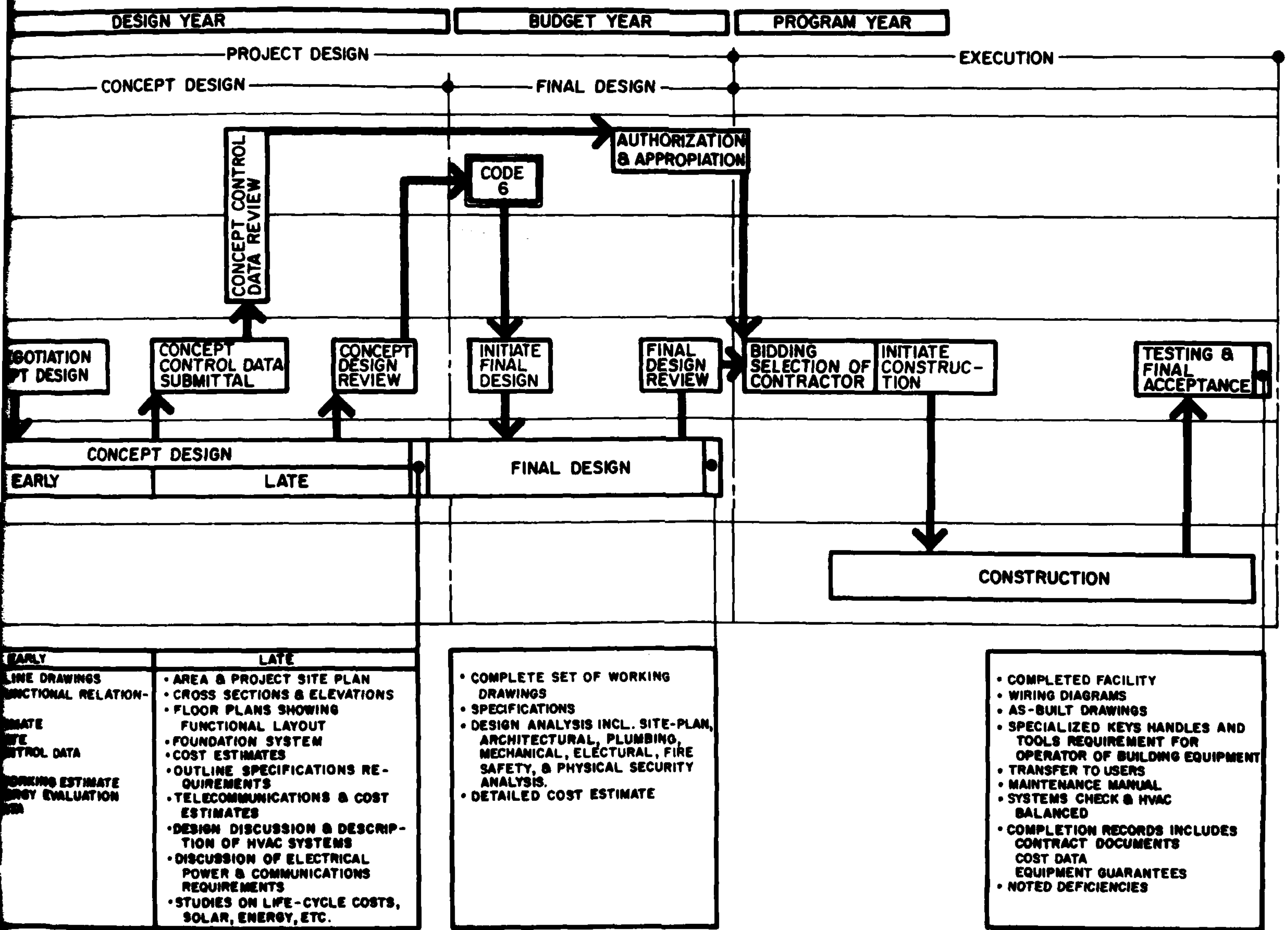


Figure 2. MCA process steps, phases, and products.



DESIGN YEAR
BUDGET YEAR
PROGRAM YEAR
PROJECT DESIGN
EXECUTION
CONCEPT DESIGN
FINAL DESIGN
CONCEPT CONTROL DATA REVIEW
AUTHORIZATION & APPROPIATION
CODE 6
GOTIATION
PT DESIGN
CONCEPT CONTROL DATA SUBMITTAL
CONCEPT DESIGN REVIEW
INITIATE FINAL DESIGN
FINAL DESIGN REVIEW
BIDDING SELECTION OF CONTRACTOR
INITIATE CONSTRUC-TION
TESTING & FINAL ACCEPTANCE
CONCEPT DESIGN
EARLY
LATE
FINAL DESIGN
CONSTRUCTION
EARLY
LATE
LINE DRAWINGS
NCTIONAL RELATION-
MATE
TE
TROL DATA
ORKING ESTIMATE
RGY EVALUATION
• AREA & PROJECT SITE PLAN
• CROSS SECTIONS & ELEVATIONS
• FLOOR PLANS SHOWING FUNCTIONAL LAYOUT
• FOUNDATION SYSTEM
• COST ESTIMATES
• OUTLINE SPECIFICATIONS RE-QUIREMENTS
• TELECOMMUNICATIONS & COST ESTIMATES
• DESIGN DISCUSSION & DESCRIP-TION OF HVAC SYSTEMS
• DISCUSSION OF ELECTRICAL POWER & COMMUNICATIONS REQUIREMENTS
• STUDIES ON LIFE-CYCLE COSTS, SOLAR, ENERGY, ETC.
• COMPLETE SET OF WORKING DRAWINGS
• SPECIFICATIONS
• DESIGN ANALYSIS INCL. SITE-PLAN, ARCHITECTURAL, PLUMBING, MECHANICAL, ELECTURAL, FIRE SAFETY, & PHYSICAL SECURITY ANALYSIS.
• DETAILED COST ESTIMATE
• COMPLETED FACILITY
• WIRING DIAGRAMS
• AS-BUILT DRAWINGS
• SPECIALIZED KEYS HANDLES AND TOOLS REQUIREMENT FOR OPERATOR OF BUILDING EQUIPMENT
• TRANSFER TO USERS
• MAINTENANCE MANUAL
• SYSTEMS CHECK & HVAC BALANCED
• COMPLETION RECORDS INCLUDES CONTRACT DOCUMENTS COST DATA EQUIPMENT GUARANTEES
• NOTED DEFICIENCIES

2

PHASE: LONG-RANGE PLANNING

ACTIVITIES

- Mobilization Planning
- Determination of Personnel Requirements to Meet Defense Needs
- Installation Planning

M C A OUTPUTS

- 5-Year Defense Program
- MACOM 5-Year Program
- Army Stationing & Installations Plan (ASIP)
- Long-Range Construction Program
- Mobilization Project Listing
- Program Objective Memorandum (POM)

RELATED DOCUMENTS

DOD 4270.1-M
ER 1110-345-100
AR 415-15
AR 415-17
AR 420-10
AR 11-27

Figure 3. Activities, outputs, and documents for long-range planning.

PHASE: MASTER PLANNING

ACTIVITIES

- Initial DD Form 1391 Preparation
- Project Development Brochure (PDB1) Preparation
- Project Definition
- Study of Site/Environmental Considerations

M C A OUTPUTS

- Master Plan (Phase I, II, III)
- Environmental Impact Assessment
- PDB1
- Front Page of DD Form 1391
- Site Studies & Selection
- Energy Resource Impact Statement (ERIS), Parts I & II

RELATED DOCUMENTS

DOD 4270.1-M	AR 210-20	AR 420-49
ER 1110-345-100	AR 210-30	AR 11-27
AR 415-15	TM 5-800-3	ETL 1110-3-282
AR 415-20		
TM 5-800-1		
AR 11-28		
AR 415-17		
TM 5-803-1		
TM 5-803-5		
TM 5-822-2		
AR 420-10		

Figure 4. Activities, outputs, and documents for master planning.

PHASE: PROGRAMING

ACTIVITIES

- Predesign Exploration & Analysis of Site
- Prepare Detailed DD Form 1391 & PDB2
- Determine Facility's Requirements
- Prepare Economic Analysis
- Preliminary A/E Selection

M C A OUTPUTS

- Functional Data
- Preconcept Control Data
  - PDB2
  - Site Plan
  - Facility's Requirements Sketch
  - Project Economic Analysis
- Detailed DD Form 1391
  - Energy Requirements Appraisal (ERA)

RELATED DOCUMENTS

DOD 4270.1-M
ER 1110-345-100
AR 415-15
AR 415-20
ER 1110-345-711
TM 5-800-1
ER 1110-345-720
AR 11-28
AR 415-17
AR 420-10
TM 5-800-3
AR 420-54
AR 420-49
AR 11-27

Figure 5. Activities, outputs, and documents for programing.

PHASE: EARLY CONCEPT DESIGN

ACTIVITIES

- Determine Design Priorities
- Space Planning
- Functional Analysis
- Site Development
- Energy Analysis
- Choose Preliminary Building Systems
- Comparison of Alternative Concepts
- Choice of Best Concept to Satisfy Programing Requirements
- Refinement of Cost Data
- Preparation of Concept Control Data
- A/E Negotiation

M C A OUTPUTS

- Schematic Design Documents
- Cost Studies
- Initial Energy Estimate
- Concept Control Data
  Facility Sketch
  Current Working Estimate (CWE)
  Results of Solar Energy Evaluation

RELATED DOCUMENTS

DOD 4210-M	TM 5-785	ETL 1110-3-282
ER 1110-345-100	TM 5-810-1	ETL 1110-3-294
AR 415-20	ETL 1110-3-256	ETL 1110-3-254
ER 1110-345-711		ETL 1110-3-243
TM 5-800-1		ETL 1110-3-248
ER 1110-345-720		ETL 1110-3-291
ETL 1110-3-332		ETL 1110-3-302
TM 5-803-5		ETL 1110-3-309
AR 420-54		
AR 420-49		

Figure 6a. Activities, outputs, and documents for early concept design.

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PHASE: LATE CONCEPT DESIGN

ACTIVITIES

- Building System Design & Analysis
- Cost Analysis
- Energy Analysis
- Interior Design
- Outline Specifications
- Landscape & Civil Design
- Budget Data Submittal

M C A OUTPUTS

- Area & Project Site Plan
- Floor Plans
- Cross Sections
- Elevations
- Outline Specifications
- Telecommunications Requirements & Cost Estimate
- HVAC System Comparison/Selection
- Design Narrative of Electrical & Lighting Systems
- Foundation System Selection & Narrative
- Cost Estimate
- Studies on Life-Cycle Cost of Solar Energy
- Budget Data Using Current Working Esti-mates and Sketch - ENG Form 3086

RELATED DOCUMENTS

DOD 4270.1-M
ER 1110-345-100
ER 1110-345-711
AR 415-20
TM 5-800-1
ER 1110-345-720
ETL 1110-3-332
ER 415-345-42
TM 5-803-5
AR 420-54

AR 420-49
TM 5-785
TM 5-810-1
ETL 1110-3-256

ETL 1110-3-302
ETL 1110-3-309
ETL 1110-3-254
ETL 1110-3-282
ETL 1110-3-243
ETL 1110-3-248
ETL 1110-3-291

Figure 6b. Activities, outputs, and documents for late concept design.

PHASE: FINAL DESIGN

ACTIVITIES

- Final Criteria Check & Incorporation of Concept Review Comments Into Design
- Prepare Working Drawings
- Prepare Final Specifications
- Generation of Bid & Contract Documents
- Prepare Final Cost Estimate

M C A OUTPUTS

- Working Drawings
- Specifications
- Design Analyses
- Detailed Cost Estimate
  - Architectural Details
  - Engineering Details
  - Site Details

RELATED DOCUMENTS

DOD 4270.1-M	AR 420-54	ETL 1110-3-302
ER 1110-345-100	TM 5-785	ETL 1110-3-309
ER 1110-345-700	TM 5-810-1	ETL 1110-3-254
ER 1110-345-711		ETL 1110-3-282
ER 1110-345-720		ERL 1110-3-248
AR 415-20		ETL 1110-3-291
TM 5-800-1		
ETL 1110-3-332		
ETL 1110-3-256		
AR 420-49		

Figure 7. Activities, outputs, and documents for final design.

PHASE: CONSTRUCTION

ACTIVITIES

- A/E Reviews Contractors O&M Procedures
- Joint Inspection of Building
- Acceptance by Using Service
- Complete As-Built Drawings & Documentation
- Construction Scheduling & Administration
- Design & Construction Evaluation
  - Visual Observations
  - Recording of Data
  - Tests
  - Written Report

M C A OUTPUTS

- Bidding Documents
- Contract Documents
- Completed Building
- Completion Records
  - Contract Documents, Cost Data, and Related Information
  - Manufacturer's Catalog, O&M Manuals, and Instructions
  - Equipment Guarantees
  - Copies of Wiring Diagrams, Maps, Records, & Complete As-Built Drawings & Specifications
- Special Keys, Handles, Tools

DD Forms 813, 813-1, 813-2 (Cost Reports)

RELATED DOCUMENTS

DOD 4270.1-M
ER 1110-345-100
AR 415-10
ER 1110-345-52
ER 1110-345-720
TM 5-800-2
EP 415-1-260
EP 415-1-261
EP 415-1-262
EP 415-1-263

Figure 8. Activities, outputs, and documents for construction.

3 ENERGY IMPACT ANALYSIS OF THE MCA PROCESS

After the functional phases of the MCA process and their interrelationships were identified, the next step was to identify energy impacts during each of these phases. Documents were analyzed (see Appendix A) to identify what energy-related decisions are being made, where they are being made and by whom, and to determine what energy requirements and controls govern the process. Comparing actions that affect energy use with how energy needs are currently handled in the MCA process yielded a list of research and development requirements (see Appendix B).

Energy Impacts of Long-Range Planning

Army mission, stationing, and mobilization decisions made during long-range planning affect energy use at all Army installations. These decisions will affect Army-wide fuel consumption and its cost since the location of facilities affects fuel availability and the overall utility cost. In addition to affecting the use of conventional fuels, the Army use of alternate energy sources (such as solar, wind, geothermal, and/or wood/biomass) will be affected. Stationing decisions affect the use of local sources of energy (such as gas, electricity, purchased steam) and passive design features (such as sun, wind, ground/earth, water, shade) due to local vegetation, topography, hydrology, geology, and climate. At existing installations, long-range decisions affect the construction, retrofit, renovation, or closure of facilities thereby affecting energy consumption for the entire installation.

Currently, consideration of energy impacts during long-range planning is minimal and deals mainly with evaluation of conventional energy supply sources. Even if the Army wanted to include energy use in long-range planning activities, the guidance, analysis tools, and evaluation procedures to assess energy impacts at this level are not available.

Energy Impacts of Master Planning

During the master planning phase, decisions are made about road networks and utility systems, the need for specific facilities, building sites, and building orientation and general configuration. These decisions affect the feasibility of using central energy plants, existing energy distribution systems, and passive solar design techniques that would help minimize the use of costly fuel sources. The terrain, vegetation, and surrounding structures influence the amount of wind and solar radiation at various sites. Anything which might restrict a facility's envelope configuration or orientation -- such as roads or surrounding facilities -- affects a designer's ability to use passive energy.

As with long-range planning, many energy impacts are not considered during master planning, except when an existing utility system is affected. Again, the tools, procedures, and guidance are not available to make energy considerations an integral part of the Army's master planning process.

Energy Impacts of Programing

During the master planning phase, a need for a facility will have been determined. Programing is the phase that sets guidelines for the design of a specific facility. A site evaluation will identify details needed to optimize passive design features. Climate data will also enter into the decisions relating to the energy consumption of the facility; the microclimate must be analyzed carefully. Functional requirements must also be carefully analyzed to determine how energy will be used in the facility and how much will be required. A great deal of information is gathered during this phase. It is important that it be done in a quick, concise, and reliable manner. Evaluation of the site and functional requirements of the facility requires the use of tools and procedures geared towards conserving energy.

Energy Impacts of Concept Design

Decisions made during early concept design will significantly affect the energy consumption of the designed facility; consequently this phase is critical to energy conservation effects. Building orientation and siting can either ignore location completely or try to maximize the site's potential for passive solar design. Envelope design, floor plan, and a building's occupancy and use also influence the use and design of passive solar designs, thus directly influencing the building's energy consumption. Since the best design from several concepts is chosen at this stage, the design features mentioned above are difficult to change later in the MCA process. Besides architectural design considerations, initial decisions are made about an energy supply system and the feasibility of alternate energy systems -- particularly solar. Energy budgets, prescriptive standards, and feasibility criteria for solar energy systems are available. However, adequate tools are needed to help designers and reviewers evaluate design compliance with the criteria, standards, and budgets. Since many alternative concepts are considered during early concept design, these tools must be quick and easy to use.

During late concept design, the selected design is further refined and building systems are selected. Many tools used in early concept design can also be used in late concept design for refinement of the design. At this stage, energy impacts occur in the selection and use of design components such as the type of exterior skin, roof materials, or floor materials. Energy impacts also occur in the design of systems such as HVAC, lighting, and fire safety. To increase energy efficiency in a proposed building, adequate tools must exist to evaluate design components and systems, and their combined effect on energy use of the building. Reliable information must be available for use in the evaluation of design components. Energy requirements should be clearly understood by designers and reviewers of their work.

Energy Impacts of Final Design

Energy impacts occur in three major areas during final design: mechanical/electrical equipment selection and sizing, material selection and building detailing, and specification documents. The energy impacts of equipment selection and sizing can be evaluated using computer programs, but tools and procedures need to be developed to evaluate the energy impact of material

selection and building detail. Key considerations should include the effectiveness of insulation; the amount of infiltration; the reliability of HVAC system controls; and most importantly, the long-term energy effectiveness of the facility. Because changes made during final design can decrease the building's energy effectiveness, the final design should be evaluated for compliance with energy budgets. Specifications should be evaluated to insure that they comply with all energy conservation data, codes, and design work.

Energy Impacts of the Overall Design Process

Two concerns affect all three phases of the design process: the Army's reliance on contractors to produce the facility designs, and the availability of energy design data. Since the Corps contracts most of its design projects, it must have methods of reviewing the work of others to ensure that a building will meet energy criteria, and that the designers have adequately addressed energy in evaluating design options. These methods of review must allow the Corps to assess designs quickly without re-analyzing the building or studying additional design options. To ensure that the designs and analysis are done properly, design data should be available in standard formats for all Army installations. The amount and format of data will depend on the specific tools that will be developed to support the design process.

Energy Impacts of Construction

Two potential energy impacts occur during construction. The first is the quality of construction, which includes the proper installation of insulation, sealing of potential air leaks, and the proper installation of HVAC systems and controls. There are no acceptance testing procedures to ensure that the final building meets the construction specifications' requirements for energy efficiency. The development of acceptance tests for solar energy systems is a difficult task; however, such procedures are being developed.[4] The second energy impact is contract modifications during construction. Corps personnel must be able to evaluate these modifications, which are a natural part of the construction process, to ensure they do not reduce the building's energy effectiveness.

Energy Research and Development Requirements

Based on the energy impact analysis, CERL identified areas where further research and development should be undertaken. The emphasis of this research should be to develop new tools, procedures, and data to support guidance and regulations, and provide the means for considering energy efficiency throughout the MCA process. From this research and development, the finished products will qualify for inclusion in existing regulations and provide up-to-date energy guidance to Army personnel. Other products will emerge that will be useful to Army personnel although not required by regulations. Training of Corps personnel will be required to implement and enforce the use of these products and existing energy guidance. Specific research and

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[4] D. M. Joncich and D. C. Johnson, Development of an Acceptance Test for Solar Energy Systems, Technical Report E-173/ADA101654 (CERL, 1981).

development requirements are listed in Table 3. Appendix B defines these problems, offers general solutions, and lists documents which may be affected.

Table 3

Research and Development Requirements

<u>Long-Range Planning</u>

Energy Assessment Procedures for Long-Range Planners

<u>Master Planning</u>

Energy Assessment Procedures for Master Planners

<u>Programing</u>

Energy Assessment Procedures for Programers
Feasibility Assessment Procedures for Programers/Designers

<u>Early Concept Design</u>

Feasibility Assessment Procedures for Programers/Designers
Energy Efficient Architectural System Design Methods
Concept Design Energy Analysis Tools

<u>Late Concept Design</u>

Energy Efficient Mechanical/Electrical System Design Methods
Concept Design Energy Analysis Tools

<u>Final Design</u>

Energy Conservative Building Material Selection and Specification

<u>General Design</u>

Evaluation of Innovative Energy Systems/Design Concepts
Incorporating Energy Considerations Into Corps Review Process
Energy Design Data

<u>Construction</u>

Energy Impacts of Construction Details/Construction Modifications
Energy Inspection/Acceptance Testing

4 CONCLUSIONS

The results of the energy impact anlaysis show that the present MCA process does not hinder the delivery of energy efficient buildings. However, the process does not ensure that energy-efficient buildings will be delivered, nor does it encourage the planner/designer to produce an energy-efficient facility. Further, the impact analysis shows that while there are significant requirements in the MCA process for considering conservation and alternate energy sources, there is not enough guidance on how to effectively address those requirements.

The present MCA process primarily considers energy during the late concept and final design phases. The MCA process does not emphasize the consideration of energy during long range, master planning, programing, early concept design, or construction, even though decisions made at these phases can significantly affect the final building's energy performance. Criteria and energy analysis tools exist for use in the concept and final design phases, but no design methods and review procedures ensure that these tools are being properly used.

Enforcement of existing energy requirements currently varies from district to district depending on their work load and staff strength. Due to the amount of other requirements that need to be met on even the simplest of projects, all existing and any new energy requirements should be consolidated and addressed in a clear and concise manner. Any tools or procedures used to meet requirements should be easy to use or follow, but still provide valid results.

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APPENDIX A:

ANALYSIS OF ENERGY IMPACT DOCUMENTS

The MCA building delivery process is defined and governed by an interrelated set of Department of Defense (DOD), Department of the Army (DA), and Corps of Engineers (CE) publications. These documents describe the procedures to be used and the requirements to be met when planning, designing, and constructing a facility. Consequently, these documents affect the energy performance of the completed facility.

CERL's first step in determining the impact of the documents on facility energy consumption was to obtain DA Pamphlet 310-1 and Engineer Pamphlet (EP) 310-1-1.[5] These pamphlets were used to identify the documents which may affect energy decisions within the MCA building delivery process (Table A1). The documents listed in Table A2 also may affect energy use, but are not discussed in this report. Next, current versions of the documents were reviewed. Finally, a summary was prepared for each document affecting facility energy use. The summaries indicate which portions of the documents have energy impacts, and provide short commentaries on how the documents affect facility energy consumption.

1. AR 210-20, Master Planning for Permanent Army Installations, 26 January 1976

Energy-Related Paragraphs

Chapter 1, General
- Paragraph 1-3a(5), Energy-Related Responsibilities of Installation Commander
- Paragraph 1-3c(1&3), Energy-Related Responsibilities of OCE
- Paragraph 1-4d, Revision of Master Plan Documents
- Paragraph 1-6, Formulation of Master Plans
- Paragraph 1-7, Departmental Review of Master Plans
- Paragraph 1-8, Submission and Revision of Master Plans

Chapter 2, Basic Information Components of Master Plan for Army Installations
- Paragraph 2-2, Basic Information Maps
- Paragraph 2-4, Analysis of Existing Facilities/Environmental Assessment Report

Chapter 3, Future Development Components of Master Plan for Army Installations

Appendix B, Master Planning Document Requirements

Appendix C, Referenced Publications

[5] Index of USACE Publications, EP 310-1-1 (OCE, June 1981), and Consolidated Index of Army Publications and Blank Forms, DA PAM 310-1 (DA, Aug 82).

Commentary

This regulation affects the preparation and review of installation master plans at all levels in the chain of command. The regulation refers to a number of Army technical manuals and regulations which deal with site planning. Because design decisions which affect facility energy consumption are made early in the master planning phase, this regulation has a significant impact on an installation's energy use.

Chapter 3 discusses the orientation of installation road networks, which have a direct impact on the orientation, siting, and solar accessibility of all sites within the network. The use of alternative energy sources and refuse-derived fuel (RDF) are not addressed on an installation-wide scale.

2. AR 210-30, Selection of Sites for Army Installations, 15 October 1979

Energy-Related Paragraphs

Chapter 1, General
  Paragraph 1-5f, Directives
Chapter 2, Site Selection Criteria
  Paragraph 2-3, Construction Feasibility
  Paragraph 2-10, Energy and Comfort Considerations
Chapter 4, Site Selection Reports
  Table 4-1. Detailed Report of Site Board

Commentary

AR 210-30 describes the responsibilities, requirements, and procedures for selecting Army installation sites.

Energy considerations during site selection are summarized in paragraph 2-10. Reference is also made to AR 22-17 for energy requirements, and to AR 420-49 and AR 420-54 for heating and air-conditioning requirements during site selection. Site report requirements are also identified. These requirements provide data for comparison of each site's features that will affect energy use.

3. AR 415-10, General Provisions for Military Construction, 2 February 1972

Energy-Related Paragraphs

Chapter 3
  Paragraph 3-2, Design Criteria and Standards
  Paragraph 3-3, Conduct of Construction

Commentary

This regulation outlines the general responsibilities and administrative policies and procedures for the MCA program. AR 415-10 has broad policy implications for two reasons. First, it deals with DOD and DA criteria and standards which determine how buildings are designed and constructed. Some of

these standards affect the efficient use of energy. Second, it defines authorities and responsibilities for actions during design and construction that impact on energy.

4. AR 415-15, Military Construction, Army (MCA) Program Development, Draft, 1982

Energy-Related Paragraphs

Chapter 3, Programing Policies and Procedures
  Paragraph 3-20, Utilities and Ground Improvements
Chapter 7, Military Construction Project Data
Chapter 8, Detailed Project Justification
  Paragraph 8-1c(8) and 8-2b, Fuel Conversions
  Paragraph 8-16, Energy Requirements
Chapter 9, Additional Data
  Paragraph 9-2c, SRP 3. Energy Requirements Appraisal
  Paragraph 9-3, Site Plans
Chapter 10, Supplemental Data
  Paragraph 10-2 (b,c, and d), Cost data

Commentary

This regulation gives guidance to all Army elements developing MCA programs. The regulation prescribes the policies, responsibilities, and procedures used in MCA program development. AR 415-15 deals with temporary or permanent facilities on military installations. The regulation covers construction activities such as planning, acquisition, minor construction, and other supporting activities.

Paragraph 3-20 defines Army policy concerning the programing of utilities and ground improvements. Supporting utilities, road networks, and parking areas are to be programed at the same time as primary facilities. The layout, orientation, and siting of these design components directly affect the energy consumption of the installation. The design and funding of landscape planting, buffer zones, screening, parks and recreational areas are required to improve the post's appearance. However, careful programing of these aesthetic considerations will allow for the use of passive solar techniques and alternative energy sources.

One of the most important chapters in this regulation (Chapter 7) describes how to prepare the DD Form 1391, "Military Construction Project Data." This form contains basic information about location, size, type of construction, facility, and cost estimates for any military construction project. DD Form 1391 is a detailed summary supported by specific justifications for a project. Since the information on this form is used to establish energy-use goals for the entire installation, various energy sources are considered for current and future uses, including alternative energy sources (see also AR 420-49).

Chapter 8, Paragraph 16, directs that an energy requirements appraisal (ERA) be prepared for each MCA project. This appraisal is for energy consumption, heating and air-conditioning systems, and water supplies. The ERA must

include energy-use impacts, actions taken to conserve energy, and alternative sources of energy. Chapter 8, Paragraph 16, also affects the programing phase of the design procedure. It requires that the estimated increase or decrease in energy consumption resulting from the project be determined by energy type. These initial figures can affect the establishment of overall consumption goals for an installation.

Chapter 9, Paragraph 3, identifies requirements for site plans. Site plans must indicate the location and arrangement of the general building envelope for the facility being proposed. This requirement restricts the possibilities for future changes in building orientation and the future use of passive solar techniques. The requirements outlined in this paragraph are to be used during master planning.

5. AR 415-20, Project Development and Design Approval, Draft, January 1982

Energy-Related Paragraphs

Paragraph 4i, Facilities
Paragraph 4j, Primary Facility
Paragraph 4k, Supporting Facilities
Paragraph 4p, Nonrepetitive Facilities
Paragraph 8, Project Development Brochure (PDB)
Paragraph 9, Developing Functional Requirements
Paragraph 10, Preconcept Control Data
Paragraph 11, Concept Design
Paragraph 12, Budgetary Data
Paragraph 13, Final Design
Paragraph 14, Current Working Estimate (CWE)

Commentary

This regulation outlines architectural and engineering processes through which requirements and criteria governing a proposed facility can be translated into project drawings, specifications, analyses, and cost estimates.

The regulation defines the stages of design development and the supporting documents required to justify that development. It indicates the requirements for preconcept control data and for concept and final design procedures. The regulation also identifies the requirements for each stage of the design process.

Paragraphs 4i, 4p, 4t, and 13 serve as a guide for the MCA project development flow chart (Appendix B). This information is important during the final phase of the design procedure.

Although this regulation does not directly concern energy use, it provides the framework for the design process and documents, and for the energy aspects of the design.

6. AR 420-10, Facilities Engineering: General Provisions, Organization, Functions, and Personnel, 15 December 1981

Energy-Related Paragraphs

All

Commentary

AR 420-10 defines the energy responsibilities of the Chief of Engineers (COE), MACOM commanders, installation commanders, facility engineers, and others involved in the Military Construction, Army (MCA) process. The importance of this regulation is that it identifies the responsibilities for the enforcement of energy criteria.

The regulation requires key officials to provide "a technical review of projects and budget estimates for the purpose of determining technical soundness, adequacy, and conformance with applicable statutes and establishes policies, practices, and standards" (Chapter 1, paragraph 1-3, section(f)3). This guidance is important during master planning and programing phases. In these phases, the facility engineer works with the district engineers to determine functional needs of the facility and ensures these needs are met in the design process. It is equally important during the review of the design to check if energy guidance has been followed.

7. ER 1110-345-100, Design Policy for Military Construction, 17 January 1977

Energy-Related Paragraphs

All

Commentary

This ER is the only document dealing with policies for stating criteria, design directives, or other written instructions for making energy changes in buildings. This regulation explains the concept of design guides. Design guides give specific information about the designs for military facilities of certain functional types. The regulation examines both the relationship of Army technical manuals to the design process, and the implementation of new criteria. Most importantly, the regulation provides an orderly procedure for the design verification of completed drawings which includes verifying corrections and suggestions. The regulation also gives general policy guidance for reviewing (or changing) energy-related statements on building construction methods and finishing materials.

Paragraph 5c defines the implementation of new criteria in three categories: routine, special, and immediate. These criteria govern the policy toward energy changes in buildings during the master planning, programing and concept design phases.

Paragraph 9 permits the use of previously untried materials or unusual or new methods when evidence shows it will result in greater economy, lower life-cycle costs, and improved construction quality.

Paragraph 11 guides the approval of bidder-initiated and Government-prepared alternative designs during the final phase of the design procedure.

Paragraph 17 establishes a process for design verification of completed drawings. It describes how to review innovative design features, equipment, and methods. This process allows statements guiding the Army's construction methods and finishing materials to be revised or altered to reflect energy conservation methods.

8. DOD 4270.1-M, DOD Construction Criteria Manual, Advance Edition, 1 June 1978

Energy-Related Paragraphs

All

Commentary

This DOD construction manual lists broad technical criteria and policy guidance for the design and construction of safe, functional, and durable facilities. These criteria will ensure that new facilities will have reasonable and appropriate maintenance and operating costs over their design lives. Detailed design criteria and procedures which may be developed and issued by DOD components must be consistent with its policy statements.

This document identifies the major criteria for everything from space allowances to wall finishes, and influences all Army-related construction. Its impact varies with the facility; however, the following constuction/design areas of all facilities are affected:

a. Site planning criteria for energy conservation.
b. Space allowances.
c. Architectural design, including window glazing.
d. Electrical criteria, including lighting levels.
e. HVAC system design.
f. Cost review in reporting the evaluation of alternative systems.

9. AR 11-28, Economic Analysis and Program Evaluation for Resource Management, 2 December 1975

Energy-Related Paragraphs

All

Commentary

This regulation establishes policy, procedures, and responsibilities for applying economic analyses to scarce resources so they can be used as efficiently and effectively as possible. Although this regulation does not specifically discuss passive solar energy or renewable energy resources, it

does mention that operation and maintenance costs of utility systems should be evaluated using economic analyses techniques. All feasible alternatives are to be systematically examined and ranked according to their benefit-to-cost relationship. When costs for R&D are a significant portion of total program cost, the decision to conduct research must be supported by an economic analysis identifying the cost savings that will result. The degree of risk, availability of resources, assessment of current technology, and identification of constraints also must be included in this economic justification.

10. TM 5-785, Facility Design and Planning, Engineering Weather Data, 1 July 1978

Energy-Related Paragraphs

All

Commentary

These weather data provide the basic climatological information necessary for the design of a facility. The weather data available in this manual includes the latitude, longitude, and elevation for each installation or site across the country; dry-bulb and wet-bulb design temperatures; prevailing wind speed and direction; solar insolation data; and heating and cooling degree day data. Such data are used to design the building envelope and mechanical systems and, therefore, directly affect the energy use of the facility.

11. TM 5-800-1, Construction Criteria for Army Facilities, 10 September 1974

Energy-Related Paragraphs

Paragraph 1.3.1.1, Semipermanent Construction
Paragraph 1.3.2.3, Site Improvement
Paragraph 3.10, Improvements
Paragraph 3.15, Roads and Streets
Paragraph 4, Site Planning Criteria
Paragraph 4.1, Master Planning
Paragraph 4.2, Siting of Buildings
Paragraph 4.3, Landscaping
Paragraph 5.2, Interior Finishes
Paragraph 8, Air-Conditioning, Evaporative Cooling, Dehumidification, Mechanical Ventilation, and Refrigeration
Paragraph 9, Heating Criteria
Paragraph 10, Criteria for Plumbing and Other Mechanical Equipment and Systems

Commentary

This manual supplements DOD 4270.1-M, which describes broad technical criteria and policy guidance for the design and construction of safe, functional, and durable facilities which will have reasonable and appropriate maintenance and operating costs over their design lives. TM 5-800-1 gives

specific guidance on detailed design criteria such as space allotments, wall finishes, and mechanical equipment.

All construction criteria in this document affect facility energy consumption. The paragraphs listed above have direct impact on energy use, yet specific energy-related guidance is seldom mentioned. For example, according to this manual, extraneous features such as overhangs, exterior screening walls, and nonfunctional ornamentation are to be avoided. However, overhangs to reduce cooling loads could be justified if the facility were eligible for air-conditioning to ensure comfort.

12. TM 5-800-3, Project Development Brochure, 15 July 1982

Energy-Related Paragraphs

Paragraph 2-3, Functional Requirements Summary
Paragraph 2-4, Facilities Requirements Sketch
Paragraph 2-5, Documentation Checklist
Paragraph 2-6, Technical Data Checklist
Paragraph 3-1, General
Paragraph 3-3, Detailed Functional Requirements
Appendix C - Section D, Mechanical, Electrical, & Utility Systems
Appendix D - Section D, Mechanical, Electrical, & Utility Systems
Appendix E - Section B, Site Development
Appendix E - Section D, Mechanical, Electrical, & Utility Systems

Commentary

This manual describes how to prepare a Project Development Brochure (PDB). The PDB identifies data necessary to program the budget and initiate the design of a new building. The PDB-1 contains preliminary project information, and the PDB-2 includes the total user requirements and complete site and utility support information. The paragraphs listed above contain specific energy-related guidance. However, every paragraph contains information which affects final energy conservation considerations because the manual explains how to determine the character, size, and relationships of functional elements for the final design.

13. TM 5-803-1, Installation Master Planning Principles and Procedures, 5 November 1970

Energy-Related Paragraphs

Paragraph 4, Basic Information
Paragraph 5, Regional and Vicinity Factors
Paragraph 7, Space Allocation Studies
Paragraph 9, Preliminary Land-Use Plan
Appendix I, References

Commentary

This manual provides information about collecting and formatting initial master planning data. The manual focuses on the conversion and development of existing installations and the disposal of excess facilities. Much of its policy guidance could affect the overall energy load of an installation.

Paragraph 4 explains the need to review a general site map to learn about the installation's physical operations. The installation's Existing Facilities Report can give basic information about existing buildings and areas designated for continued similar use, alternate uses, and proposed future uses.

Paragraph 5 lists master planning considerations related to the region and vicinity in which an installation is located. These issues should be examined before the internal aspects of a military installation are studied.

Paragraph 9 explains the fifth stage in the evolution of a general site plan: well-defined, space-allocation areas are combined with the required street circulation to produce the preliminary land-use plan.

These paragraphs have important energy implications at both the facility and installation levels, yet energy impacts are not directly assessed during any of the master planning stages outlined in this document.

14. TM 5-803-5, Installation Design, 1 March 1981

Energy-Related Paragraphs

Paragraph 2-2(c)(4), Energy Conservation
Paragraph 3-1(I), Climate Considerations
Paragraph 3-2(A), Adapt Building Designs to Natural Site Conditions
Paragraph 3-4, Adapt Buildings to Natural Site Conditions
Chapter 6, Planting
Chapter 13, Utilities

Commentary

TM 5-803-5 is intended to help all personnel involved in the planning, programing, and design of installations produce high quality designs. The manual emphasizes improving the visual environment. Related subjects addressed include circulation systems, energy conservation, barrier-free site design, historic preservation, planting materials, playgrounds, use of signs, lighting, and street furniture.

Paragraph 2-2(c)(4) addresses energy conservation on a broad scale. It briefly addresses land use, transportation, building orientation, massing and detailing, and building/site interface.

Paragraph 3-1(I) states that recent trends in installation design have used an overreliance on buildings mechanical systems to overcome climate

conditions and provide a comfortable living/work environment. Energy can be saved through the proper building siting, orientation, and planting design.

Paragraph 3-2(A) discusses the need to harmonize building designs with natural site conditions. Building designs should effectively incorporate the topography, vegetation, tree cover, climate, and views. Section 3-4 is a design guide for adapting buildings to natural site conditions.

Other sections may not mention energy conservation directly but nevertheless have an impact on energy use. These sections cover topics on road layout, grouping of buildings, planting, and utilities.

15. TM 5-822-2, General Provisions and Geometric Design for Roads, Streets, Walks and Open Storage Areas, 1 April 1977

Energy-Related Paragraphs

Paragraph 2.2.2, Planning
Paragraph 2.3.1, Geometric Design
Paragraph 3.3.2, Design Controls
Paragraph 3.3.2.1, Topography and Land Use

Commentary

This manual establishes general provisions and geometric design criteria for roads, streets, walks, and open storage areas at military installations.

This manual affects the master planning phase of the design process. Roads and streets have a major impact on building orientations and, therefore, building energy consumption. However, energy considerations are not part of the design criteria specified for roads and streets in this document.

16. ER 1110-345-700, Design Analysis, 19 February 1982

Energy-Related Paragraphs

All

Commentary

The design analysis described in this ER summarizes all the functional and engineering criteria, design information, and calculations pertaining to project designs, plans, and specifications. This ER is for use by Army personnel in reviewing and approving installation designs. This regulation identifies those criteria used in design decisions made throughout the design process. No specific paragraphs deal solely with energy; although energy considerations are included throughout the ER. For example, the section on mechanical systems examines energy use implications for solar energy systems, electrical systems, heat pumps, energy conservation, and mechanical ventilation. This document specifies the need for design load calculations and life-cycle cost analyses to justify decisions about the design of alternative energy systems. The design load calculations and life-cycle cost analysis are

examined during the mechanical systems analysis, which also considers energy-recovery systems and the results of total-energy and selective-energy studies. The final design decisions must justify the selection of compatible energy sources, mechanical systems, and equipment for minimum-energy dependency and low life-cycle costs.

17. ETL 1110-3-332, Economic Studies, 22 March 1982

Energy-Related Paragraphs

Part I. General Design Studies
Part II. Special Directed Studies
1. Extraordinary Energy-Saving Design Initiatives (Nonsolar)
2. Extraordinary Energy-Saving Design Initiatives (Solar)

Commentary

Part I is a general discussion on using a life-cycle cost analysis (LCCA) to determine the economic ranking of design alternatives.

Part II provides specific information on doing an economic evaluation of energy conservative alternatives. Information, guidance, and references are provided that outline current policy and procedures to follow to meet the statutory requirement to perform such studies.

The criteria and standards that cover the conduct of LCCAs is contained in the Code of Federal Regulations (CFR) and National Bureau of Standards (NBS) handbook number 135.[6] The purpose of ETL 1110-3-332 is to provide insight and guidance for performing the LCCAs.

18. EP 70-1-2, Army Facilities Energy Research and Development Plan, 25 May 1982

Energy-Related Paragraph

All

Commentary

The Army Facilities Energy Plan states that to meet the goal of a 20-percent reduction in energy for FY85 there must be a rededication to energy conservation principles. This plan discusses low-cost or no-cost options that will help meet the energy-savings goal with minimal impact on morale of personnel and greater dollar savings for the Army. The plan also emphasizes the

[6] Code of Federal Regulations (CFR), Title 10, Part 436, Subpart A (10CFR436A) and William D. Kovacs, Lawrence A. Salomone, Felix Y. Yokel, Energy Measurement in the Standard Penetration Test, NBS Building Science Series 135 (National Bureau of Standards, August 1981).

importance of updating the Army's energy guidance as described in the following publications: Army Facilities Engineers Plan (AFEP), Army Energy Plan (AEP), Army Facilities Energy Program, and MACOM Facilities Energy Plans.

According to the energy plan, the 20-percent reduction goal can be met through more effective management and planning. Management structure and energy programs are outlined. Economic analysis, annual energy management, planning, and energy awareness training are emphasized for meeting the energy goals.

Specific measures for conserving energy are addressed in the appendices.

19. AR 11-27, Army Energy Program, 15 October 1982

Energy-Related Paragraphs

All

Commentary

This regulation describes how the Army will manage energy resources effectively and efficiently. The regulation identifies policies and procedures for energy procurement and supply. It also recommends mandatory and voluntary requirements for energy conservation in operations and training, buildings and installations, and products and equipment. The regulation also establishes policies and procedures for the Army's input to the Defense Energy Information System (DEIS), the DA Advisory Group on Energy (AGE), and energy conservation awards. Instructions on preparing energy resource impact statements are included.

This regulation strongly encourages the use of innovative practices to reduce energy consumption, increase energy efficiency in existing facilities, and make new facilities and equipment as energy-efficient as possible. It directs that energy conservation be considered in the decision process during the planning, design, and construction of new equipment and facilities. The Army must select energy resources by considering price, availability, and environmental compatibility and renewability. Renewable energy sources (solar, wind, and geothermal energy) are to be preferred over nonrenewable sources when other considerations are balanced. Life-cycle cost analyses must be used to justify the procurement of special types of energy forms (e.g., solar, geothermal, and wind energy) which permit an overall reduction in energy consumption, particularly for nonrenewable energy sources. Dual fuel capability must be achieved where practical.

20. AR 420-44, Utilities Management Analysis, 26 March 1973

Energy-Related Paragraphs

Paragraph 6, Minimum Measures
Paragraph 12, Performance Data To Be Recorded on DA Form 2869

Commentary

This regulation attempts to ensure an efficient use of heat, electricity, and water. It encourages the establishment of conservation programs to help facilities provide utility services efficiently and economically. This regulation can affect the programing, early concept, and late concept design phases.

21. AR 420-49, Heating Energy Selection and Fuel Storage, Distribution, and Dispensing Systems, 18 November 1976

Energy-Related Paragraphs

Chapter 2, Heating Systems
  Sections I through V
  Section VIII
Chapter 3, Energy Utilization

Commentary

This regulation sets policy and criteria for: (1) the operation, maintenance, and repair of boiler plants and heating systems, (2) the selection of energy sources for conversion and new construction, (3) the quality control of solid fuels, and (4) the maintenance and repair of fixed petroleum storage and dispensing facilities.

This document applies to all installations and activities owned or controlled by the Army. AR 420-49 can affect the programing, early concept design, and late concept design phases of the design process. The regulation directs Army personnel to consider alternate energy sources, dual plants (solid fuel and oil), conversion of plants to use different or alternative fuel sources, and economic feasibility studies during the programing and concept design phases.

22. AR 420-54, Air-Conditioning, Evaporative Cooling, Dehumidification and Mechanical Ventilation, 6 August 1973

Energy-Related Paragraphs

Chapter 2, Policy
  Paragraph 2-2, Eligibility for Installation
  Paragraph 2-3, Central (Air-Conditioning) Plant
  Paragraph 2-4, Heat Pumps
  Paragraph 2-6, Nonpermanent Construction
Chapter 3, Section II, Programing Criteria
Chapter 4, Exceptions to Policy
Chapter 5, Eligibility of Facilities for Air-Conditioning, Evaporative Cooling, Dehumidification, or Mechanical Ventilation

Commentary

This regulation outlines policies and establishes procedures for installing air-conditioning, evaporative cooling, dehumidification, and mechanical ventilation equipment and systems in existing buildings. The regulation identifies installation criteria, eligibility requirements, priorities for programing and exceptions to the policy.

AR 420-54 can affect the programing, early concept, late concept, and final design phases. The regulation establishes weather zones and the eligibility of facilities for different types of cooling, dehumidification, and ventilation systems. The energy used to ensure comfort in the building during hot months is affected by design actions taken to minimize heat gain and promote ventilation.

23. ETL 1110-3-243, Engineering and Design: Unitary Heat Pumps, 30 October 1975

Energy-Related Paragraphs

All

Commentary

This ETL lists the basic criteria for considering unitary heat pumps and requires a thorough engineering analysis of all available energy sources and systems for a facility. The ETL also requires that any heat pumps purchased be certified by the Air-Conditioning and Refrigeration Institute (ARI) and meet certain minimum coefficients of performance (COPs). A moratorium is imposed on the use of electric resistance heating.

24. ETL 1110-2-248, Domestic Hot Water Temperature, 30 November 1979

Energy-Related Paragraphs

All

Commentary

To conserve energy, this ETL mandates the use of low domestic hot water temperatures in all Army facilities. In facilities occupied during two shifts, automatic control is needed to turn off hot water when the facility is unoccupied.

25. ETL 1110-3-254, Use of Electrical Power for Comfort Space Heating, 24 August 1976

Energy-Related Paragraphs

All

Commentary

This ETL restricts the use of electric power for comfort space heating. Conventional electric resistance heating is prohibited -- except in a few cases -- because of the trends toward increasing energy costs, time-of-day rates, higher demand costs, and shorter demand periods. This ETL affects the concept design phase of the MCA process.

26. ETL 1110-3-256, Mechanical Design Guidance, 28 September 1976

Energy-Related Paragraphs

All

Commentary

This ETL describes how to assess life-cycle costs and meet energy conservation requirements during the design of mechanized systems and controls. The ETL lists various mechanical systems and controls which operate with lower life-cycle costs, thus minimizing building energy use. This guidance is being used until TM 5-810-1 is revised.

27. ETL 1110-3-282, Engineering and Design: Energy Conservation, 10 February 1978

Energy-Related Paragraphs

Paragraph 1, Site Considerations
Paragraph 2, Architectural
Paragraph 3, Mechanical
Paragraph 4, Electrical

Commentary

This ETL lists specific energy conservation measures which are to be applied to the site and to the architectural, mechanical, and electrical systems of all new facilities.

28. ETL 1110-3-294, Engineering and Design: Interior Temperatures, 15 September 1978

Energy-Related Paragraphs

All

Commentary

This ETL specifies a comfort heating design temperature of 68°F and a comfort cooling design temperature of 78°F for the inside of buildings. These temperatures are mandated by the energy conservation program in an effort to save energy consumption of nonrenewable resources. The temperatures specified are for living areas and administrative areas in Army buildings.

29. ETL 1110-3-302, Evaluation of Solar Energy, 14 March 1979

Energy-Related Paragraphs

All

Commentary

This ETL responds to the Military Construction Authorization Act, Public Law 95-356. This law requires that the designs of 25 percent of all new facilities and 100 percent of new family housing include solar energy systems -- if such systems are economically feasible. To encourage the consideration of passive design techniques (e.g., building orientation, number and location of windows) and solar systems (as they become economical), the ETL proposes that more facilities be designed to allow solar retrofit. This ETL affects the concept design phase and is applicable to all MCA projects that began design after 7 December 1978.

30. ETL 1110-3-309, Interim Energy Budgets for New Facilities, 30 August 1979

Energy-Related Paragraphs

All

Commentary

This ETL specifies energy conservation performance standards (in BTUs per square foot) for all new Army facilities. The step-by-step guidance requires that design studies be done at the concept stage of the design process. These studies must use current building energy-use criteria and must show that the design complies with energy standards. An economic study must be conducted for all alternatives, which are then ranked. Acceptable alternatives must satisfy minimum established requirements* for the project and the Military Construction Program, while permitting future solar energy use.

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* Health; safety; livability; initial, life-cycle, and operation and maintenance costs; security, and energy conservation.

The energy budgets established in this ETL apply to all new facilities, including those for which design had not progressed beyond the 35-percent level as of 30 August 1979.

Table A1

Documents Affecting MCA Facility Energy Consumption
Reviewed in This Report

Process-Related Documents

AR 210-20	Master Planning for Permanent Army Installations, 26 January 1976
AR 210-30	Selection of Sites for Army Installations, 15 October 1979
AR 415-10	General Provisions for Military Construction, 2 February 1972
AR 415-15	Military Construction, Army (MCA) Program Development, 4 December 1975
AR 415-20	Project Development and Design Approval, 15 May 1974
AR 420-10	Facilities Engineering: General Provisions, Organization, Functions, and Personnel, 15 December 1981
ER 1110-345-100	Design Policy for Military Construction, 14 December 1973

Design-Related Documents (indirectly affect energy considerations)

DOD 4270.1-M	DOD Construction Criteria Manual, 1 June 1978
AR 11-28	Economic Analysis and Program Evaluation for Resource Management, 2 December 1975
TM 5-785	Facility Design and Planning, Engineering Weather Data, 1 July 1978
TM 5-800-1	Construction Criteria for Army Facilities, 10 September 1974
TM 5-800-3	Project Development Brochures, 15 July 1982
TM 5-803-1	Installation Master Planning Principles and Procedures, 5 November 1970
TM 5-803-5	Installation Design, 1 March 1981
TM 5-822-2	General Provisions and Geometric Designs for Roads, Streets, Walks and Open Storage Areas, 1 April 1977
ER 1110-345-700	Design Analysis, 19 February 1982

Table A1 (Cont'd)

ETL 1110-3-332	Economic Studies, 22 March 1982
Energy-Related Documents	
EP 70-1-2	Army Facilities Energy Research and Development Plan, 25 May 1982
AR 11-27	Army Energy Program, 15 October 1982
AR 420-44	Utilities Management Analysis, 26 March 1973
AR 420-49	Heating Energy Selection and Fuel Storage, Distribution, and Dispensing Systems, 18 November 1976
AR 420-54	Air-Conditioning, Evaporative Cooling, Dehumidification and Mechanical Ventilation, 6 August 1973
ETL 1110-2-248	Domestic Hot Water Temperature, 30 November 1979
ETL 1110-3-243	Engineering and Design: Unitary Heat Pumps, 30 October 1975
ETL 1110-3-254	Use of Electrical Power for Comfort Space Heating, 24 August 1976
ETL 1110-3-256	Mechanical Design Guidance, 28 September 1976
ETL 1110-3-282	Engineering and Design: Energy Conservation, 10 February 1978
ETL 1110-3-294	Engineering and Design: Interior Temperature, 15 September 1978
ETL 1110-3-302	Evaluation of Solar Energy, 14 March 1979
ETL 1110-3-309	Interim Energy Budgets for New Facilities, 30 August 1979

Table A1 (Cont'd)

Draft Documents Also Reviewed

AR 415-15	Military Construction Army (MCA) Program Development, 1982, 1981, 1979 Drafts
AR 415-20	Project Development and Design Approval, January 1982, August 1981 Drafts
ER 1110-345-100 (Change 3)	Design Policy for Military Construction, January 1977 Draft
DOD 4270.1-M	Construction Criteria, Advance Edition, 1 June 1978; and Undated Draft addition to document, Chapter 7, Electrical Criteria

Table A2

Documents Affecting MCA Facility Energy Consumption Not Reviewed In This Report

Process-Related Documents

AR 1-1	Planning, Programing and Budgeting Within the Department of the Army, 25 May 1976

Design-Related Documents

AR 200-2	Environmental Quality: Environmental Effects of Army Actions, 1 September 1981
AR 405-45	Inventory of Army Military Real Property, 18 March 1977
AR 415-2	DOD Construction Criteria, 26 June 1973
AR 415-17	Cost Estimating for Military Programing, 15 February 1980
AR 415-28	Department of the Army Facility Classes and Construction Categories (Category Codes), 1 November 1981
AR 420-16	Facilities Engineering Reports, 15 March 1981
TM 5-800-2	General Criteria: Preparation of Cost Estimates; Military Construction, 2 March 1959
TM 5-807-7	Color for Buildings, 15 July 1974
TM 5-830-4	Planting and Establishment of Trees, Shrubs, Ground Cover and Vines, 15 June 1976
ER 18-1-35	Automated Military Construction Progress Reporting System (AMPRS), 18 April 1980
ER 415-3-11	Feedback Information, 14 August 1981
ER 415-35-1	Control of DA Execution Programs Through Authorization and Funding Actions, 5 December 1980
ER 415-345-42	Costs, Cost Estimating and Reserves for Contingencies, 1 May 1978
ER 715-1-8	Architect-Engineer Contract Administration System (ACASS), 1 August 1979
ER 1110-23-1	Planning, Engineering, and Design Services, 12 February 1973
ER 1110-345-52	Design and Construction Evaluation (DCE), 14 December 1979

Table A2 (Cont'd)

ER 1110-345-101	Current Design Information System, 6 May 1968
ER 1110-345-710	Drawings, 17 April 1981
ER 1110-345-711	Standard Designs by Field Offices, 30 April 1974
ER 1110-345-720	Specifications, 17 January 1977
ER 1180-1-6	Quality Management, 24 April 1978
EP 415-1-260	Resident Engineers Management Guide, 15 October 1973
EP 415-1-261	Construction Inspector's Guide: General Information and Sitework, November 1981
ETL 1110-3-208	Design Criteria Feedback Inspections, 13 May 1974
Energy-Related Documents	
TM 5-804-2	Solar Energy Systems, 15 August 1982
TM 5-810-1	Mechanical Design: Heating, Ventilating, and Air Conditioning, 1 Jaunuary 1965
TM 5-810-2	High Temperature Water Heating System, 1 March 1977
EP 415-1-262	Construction Inspector's Guide: Architectural and Structural Features in Building Construction, June 1965
EP 415-1-263	Construction Inspectors' Guide: Mechanical and Electrical Features of Building Construction, August 1969
ETL 1110-3-291	Installation of Permanent Utility Meters, 28 July 1978
Reference Documents	
ETL 1110-1-111	Engineering and Design: Rescissions, 17 November 1980
EP 310-1-1	Index of USACE Publications, June 1981
EP 1110-345-2	Index of Designs for Military Construction, 18 January 1980
DA PAM 310-1	Consolidated Index of Army Publications and Blank Forms, 1 November 1982

APPENDIX B:

ENERGY RESEARCH AND DEVELOPMENT REQUIREMENTS

The energy impact analysis of the MCA building delivery process identified the energy research and development requirements described in this appendix. If energy conservation is to be made an integral part of the MCA process, these R&D requirements must be addressed. Each R&D requirement is described briefly, its effects on facility energy consumption are discussed, and documents related to the requirement are listed.

Energy Assessment Procedures for Long-Range Planners

Background

Long-range planners decide the overall distribution of Army resources. Force structure and stationing decisions made by planners affect the availability and cost of nonrenewable fuels and the use of renewable/alternate energy resources at individual installations and for the Army as a whole. To minimize the cost and adverse impacts of not planning for energy conservation during long-range planning, energy assessment procedures are needed.

R&D Requirement

Procedures are needed by long-range planners to assess energy impacts of their decisions. These procedures should analyze different regions for the possible placement of installations. These procedures should assess the energy impacts of using nonrenewable fuel sources, passive energy potential, alternate sources, and variations in the intensity and type of energy use. The energy impact of mobilization activities concerns should also be addressed through similar procedures evaluating the same impacts, but using mobilization criteria.

Related Documents

Documents related to this issue include DOD 4270.1-M, ER 1110-345-100, AR 415-15, AR 415-17, and AR 11-27.

Energy Assessment Procedures for Master Planners

Background

Master planners determine the general configuration of an installation. This includes road and utility system layout and the requirements for and location of specific facilities. Master planning decisions affect the feasibility of using central heating plants, energy distribution systems, and renewable or recovered energy in a facility.

Site planning affects the amount of energy needed to heat, cool, and ventilate structures. All project elements (structures, land-use areas, roads, parking areas, walks) must be properly aligned with each other and placed on the site for functional, operational, and energy efficiency.

The Army Energy Program states that "renewable energy sources (solar, wind, and geothermal energy) will be given preference over nonrenewable sources (coal, natural gas, purchased electricity, liquified petroleum gas and petroleum) when the other considerations are balanced."[7] To support this directive, solar access must be provided for all existing or future structures.

The layout of road and utility system distribution networks can restrict building envelope and orientation configurations and have impact on the use of renewable resources in a facility. In addition, decisions about the layout of the utility system affects the use of existing central plants and distribution systems for a facility.

The use of recovered energy, including the use of large- and small-scale cogeneration systems and heat recovery devices, is also affected by the siting of facilities and utility systems. This, in turn, affects operations and processes which are done in these buildings.

Because the tools, procedures and guidance to make consideration of energy an integral part of the master planning process are not currently available, most energy impacts are not considered during the master planning process.

R&D Requirement

An energy assessment procedure should be developed for master planners. The procedure would ensure that the layout of road and utility distribution systems maximize an installation's energy-conservation potential. The procedure should also help master planners select sites which allow renewable energy resources to be used as much as possible, thus minimizing facility energy consumption. This procedure should locate and evaluate natural and manmade features that give a site free-energy potential -- favorable seasonal wind patterns, windbreaks, vegetation, solar access, and existing structures and energy delivery systems. The procedure should consider community energy production and sites which could accommodate underground structures. Finally, the procedure should allow master planners to locate facilities according to function and energy requirements. Buildings should be oriented towards each

[7] AR 11-27, paragraph 2-2.b.

other to allow heat recovery and waste heat from one structure to be used as much as possible by another.

Related Documents

Documents which impact or would be affected by this procedure include: AR 11-27, AR 11-28, AR 210-20, AR 210-30, AR 420-44, TM 5-803-1, TM 5-803-3, and TM 5-822-2.

Energy Assessment Procedures for Programers

Background

Once the need for a facility is determined by the master planning process, facility programers define the guidelines for the design of the specific facility. Programers define the functional requirements of the facility and evaluate the site selected for the facility. Much information about the facility is rapidly developed during the phase. Many decisions made during this phase will affect the facility's energy consumption once constructed.

R&D Requirement

The procedures used by programers to evaluate the site and determine the functional requirements for a facility must be expanded to consider energy conservation. These procedures should allow programers to define functional requirements and perform an evaluation of the facility's site which will enable the facility to meet all functional requirements with a minimal operating cost.

Related Documents

TM 5-803-1 and TM 5-803-3 are related to this issue.

Feasibility Assessment Procedure for Progamers/Designers

Background

Army guidance requires that alternate energy sources be considered for each facility. However, decisions made during the programing and early concept design phases may preclude later consideration of some alternate sources. To ensure that Army makes maximum use of alternate energy sources, the feasibility of using alternate energy sources in each facility must be assessed during the programing and very early design phase.

R&D Requirement

Procedures should be developed for use by programers/designers in assessing the feasibility of alternative energy sources for a facility. These procedures should include active and passive solar, wind, geothermal, and biomass energy sources. The procedures developed must be quick, easy to use, and accurate for all types of Army facilities.

Related Documents

ETL 1110-2-248, 1110-3-282, and 1110-3-302 are related to this issue.

Energy Efficient Architectural System Design Methods

Background

Early concept design activities include determining the building site and orientation, developing design alternatives which satisfy the functional requirements, and selecting the "best" design alternative. Once a design alternative is selected, many design features including the building floor plan, envelope design, and orientation are difficult to change. These features can significantly affect the amount of energy used at the facility. Therefore, energy considerations must be an integral part of the building siting process and the development of the design alternatives. Design procedures which consider energy conservation are needed for building siting and for the development of alternative designs.

R&D Requirement

A trade-off procedure should be developed which allows designers to produce alternative designs based on functional needs, energy conservation requirements, and regional design concepts. The procedures should help designers meet the building's functional and special requirements, its HVAC, waste heat usage, and lighting requirements. The trade-off procedure should maximize the use of passive heating, natural ventilation, and daylighting to limit the facility's energy consumption. The following passive energy strategies also should be considered by the design procedure: double-shell passive structures, earth-sheltering, hybrid HVAC systems, zero-energy building, passive humidity controls, trombe walls, roof ponds, prefabricated ventilation systems, and solar thermal systems. The procedure should consider regional alternatives to ensure effective, economical use of energy conservation measures. Such measures should include regional design methods for passive humidity control, ventilation, heating and cooling.

A procedure should also be developed to allow designers to select the most energy-efficient building location on a given site. Regional and local factors, existing facilities, vegetation, solar access, wind, topography, road and site orientation should be considered through this procedure.

Once a general building site has been selected, the orientation of the building can significantly influence its ultimate energy consumption. The orientation and shading of the building affect solar access. The wind patterns and topography determine whether natural ventilation can be used. Vegetation can greatly reduce air-conditioning demands. A site development procedure based on these factors should be used to determine the optimum location and orientation of design alternatives, and to evaluate the alternatives for free energy at the site.

Related Documents

Energy documents related to the early concept design methods include DOD 4270.1-M, AR 420-54, AR 420-49, TM 5-785, TM 5-803-1, TM 5-803-5, ETL 1110-3-282, ETL 1110-3-302, and ETL 1110-3-309.

Energy Efficient Mechanical/Electrical System Design Methods

Background

During late concept design phase, the building mechanical system concept is selected, and its design is initiated. The lighting system concept is also selected during this phase. If building energy efficiency is to be optimized, the most energy efficient design concepts must be selected for these systems. These concepts are very difficult to change later in the design process.

R&D Requirement

A trade-off procedure should be developed to justify the choice of hybrid passive/active or conventional/mechanical systems based on efficiency, cost, and efficient use of renewable resources. This procedure should evaluate (1) costs of installing a specific mechanical system, (2) its energy costs, and (3) its maintenance costs. The following design concepts should be considered: passive, active, hybrid, annual cycle, alternate energy, and conventional. The procedure should consider all functional needs of the facility and the potential energy systems. The procedure should provide the designer with options to ensure the optimum use of renewable resources and minimum life-cycle costs.

A similar trade-off procedure should be developed to justify the choice of the lighting system concept. This procedure should (1) evaluate lighting system requirements; (2) determine the installation, energy, and maintenance costs for various lighting systems, and (3) consider using natural lighting where possible. The procedure should provide the designer with lighting system options which minimize life-cycle costs.

Related Documents

The following documents pertain to the design of mechanical systems: AR 11-28, 420-44, 420-54, and ETL 1110-3-256, 1110-3-282, 1110-3-296, and 1110-3-309.

Concept Design Energy Analysis Tools

Background

The effective use of architectural and mechanical system design procedures depends on the availability of adequate analysis tools. Analysis tools must be developed to assist designers in evaluating the impact of building components and systems on building energy consumption. The existing energy analysis tools allow designers to evaluate the energy performance of most conventional building designs. However, these tools are cumbersome to use. These tools either require a large amount of detailed information about the building design or require a large effort on the part of the designer. Consequently, an energy analysis is typically performed only during the last stages of concept design for the single design concept which has been selected. Most of the decisions which affect the building's energy consumption have been made by the concept design phase; thus, the energy analysis has little impact on the building's energy efficiency. If the energy design of a facility is to be improved, then energy analysis tools must allow designers to more easily evaluate design options when the design alternatives are being developed.

Additionally, few energy analysis tools currently exist for evaluating unconventional building design concepts such as passive systems, alternate energy sources, or hybrid mechanical systems.

R&D Requirement

Energy analysis tools should be developed which provide a *rapid* evaluation of a design alternative using a limited description of a facility. During early concept design, many alternative concepts for the facility are produced which should be evaluated for energy effectiveness. Because there may be many alternatives and a limited amount of time to evaluate them, the energy analysis tools must allow for the quick and accurate analysis of alternatives using minimal information on the facility. In addition, the analysis tools must be comprehensive enough to analyze passive and other alternative design concepts. The tools must include an evaluation of the facilities' mechanical systems to tentatively determine whether they comply with a predetermined energy budget.

Analysis tools should be developed to determine the effectiveness of advanced passive solar concepts and to evaluate the relationships between passive and conventional systems. Various trade-offs must be evaluated. Examples of such tradeoffs include: artificial lighting versus daylighting (heat loss versus heat gain), underground versus conventional structures, passive strategies versus conventional mechanical systems, and thermal mass versus insulation. Analysis tools to perform these evaluations must complement existing procedures.

Analysis tools are also required for evaluating alternate energy systems such as active solar, wind, geothermal, and biomass. These tools should accurately predict the performance of each alternative energy system and should complement existing energy analysis tools.

Finally, analysis tools for evaluating lighting systems are required. These tools should allow designers to quickly evaluate alternative lighting system design concepts.

Guidance on the applicability and use of all these tools should also be developed.

Related Documents

Related documents include ER 1110-345-700, ETL 1110-3-256, ETL 1110-3-302, and ETL 1110-3-309.

Energy Conservative Building Material Selection and Specification

Background

Proper selection of building materials can greatly improve the energy efficiency of a building. For example, the proper use of thermal mass and insulation can significantly reduce a building's energy demands. Currently, there is very little guidance on the use of energy-conservative materials such as masonry, concrete, phase-change materials, water mass, roof ponds, and moveable insulation. Once energy conservative materials are selected, building specifications must be written to ensure the energy conservative materials are actually used in the building.

R&D Requirement

Guidance on selecting the most energy conservative materials for a building should be produced. The Corps building specification system should be reviewed to ensure that energy efficient building materials can be specified.

Related Documents

TM 5-800-1, DOD 4270.1-M and ETL 1110-3-282 pertain to material selection. AR 415-10 relates to building specifications.

Evaluation of Innovative Energy Systems/Design Concepts

Background

The use of unconventional design concepts such as earth-sheltered buildings, double-shelled buildings, trombe walls, roof ponds, and phase-change materials can save energy. Unconventional building systems can also result in energy savings. Such systems include annual-cycle energy systems, solar photovoltaic and thermal energy systems, chemical lighting and heating systems, optical fiber lighting systems, and advanced passive solar systems. Advanced building control concepts can save significant amounts of energy in certain applications. Also, advanced HVAC system concepts can greatly reduce a facility's energy consumption.

R&D Requirement

Use of these innovative or unconventional energy systems and design concepts for Army facilities should be evaluated. Guidance should be produced indicating the applicability of these advanced concepts to Army facilities.

Related Documents

AR 420-49, AR 420-54, TM 5-810-1, TM 5-815-2, ETL 1110-3-282, 1110-3-243, 1110-3-302, 1110-3-282, and 1110-3-309 are related to this issue.

Incorporating Energy Considerations Into Corps Review Process

Background

Because of the importance of energy conservation to the Army, the Corps' review process for new facility designs must include an evaluation of their energy effectiveness. This evaluation should ensure that the design complies with all the Corps design guidance concerning energy use and the design energy budget. Presently, the energy review of a facility design is difficult because no standard procedure is available.

R&D Requirement

A review procedure should be developed to ensure that facility designs have met all Corps energy guidance. The procedure must allow the reviewer to quickly check the designs against all applicable Corps guidance, and allow the reviewer to validate the energy analysis performed for the facility to show compliance with the design energy budget. The procedure should require designers to provide a minimum amount of information to assist in the review process. This standard input submittal would ensure that all Corps energy reviews are performed consistently.

Related Documents

The following documents deal with the Corps' review process: AR 415-20, ER 1110-345-700, ER 1110-345-100, and ETL 110-3-309.

Energy Design Data

Background

Although data on weather, solar energy, and degree days at many locations are available, only a few sites have enough data to completely analyze free-energy potential.

R&D Requirement

A standard format should be developed for recording climate and solar data to provide a consistent data base for assessing a site's free-energy potential. Such a format should allow a consistent recording of temperatures, humidity, precipitation, wind speed and direction, solar altitude and declination, isolation, and heating and cooling degree days. This format would make it easier for designers to assess a site's free-energy potential and to compare siting alternatives. Data for all locations of interest to the Army should be compiled in this format.

Related Documents

Related documents include TM 5-785, ETL 1110-3-282, and ETL 1110-3-302.

Energy Impacts of Construction Details/Construction Modifications

Background

Construction details such as methods of attaching insulation and the use of moisture barriers can affect the final building's energy efficiency. Changes in construction methods or substitution of materials during construction also can have significant energy impacts.

R&D Requirement

A procedure should be developed to ensure that construction methods produce the most energy-efficient facility possible, and to ensure that modifications during construction do not adversely affect the facility's energy efficiency.

Related Documents

Related documents include AR 415-10, TM 5-800-1, and ETL 1110-3-282.

Energy Inspection/Acceptance Testing

Background

The energy consumption of a building is greatly influenced by (1) the quality of its construction, (2) the quality of the installation of the various building systems, and (3) the operation of those systems. If the architectural and mechanical systems of the building are correctly installed and operated as designed, energy efficiency will be maximized.

R&D Requirement

Procedures such as an energy inspection checklist should be developed for use during facility construction to ensure the quality of construction. Also, procedures should be developed for testing the building's systems as part of final acceptance activities. These procedures should test architectural, mechanical, and electrical systems.

Related Documents

AR 415-10 and TM 5-800-1 pertain to this issue.

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